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THE EFFECTS OF EARLY EXPERIENCE ON SUBSEQUENT EMOTIONALITY AND RESISTANCE TO STRESS[1]

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ALTHOUGH there is a steadily increasing number of studies dealing with the effects of early experience on behavior, relatively few of these investigations have been concerned with emotionality. The research reported here is concerned with the effects of various types of early experiences on emotionality and resistance to stress in the rat. It was prompted by a reinterpretation of previous findings in this area, hence the following review is particularly pertinent.

One should mention at the outset that despite the amount of literature purporting to deal with the effects of early experience, there are, in fact, very few studies which actually bear on this subject. Unless one manipulates both young and old individuals in the same manner, one is not investigating the effects of *early* experience but only the effects of *previous* experience. Unless it is known that a particular type of experience does not effect the same changes in the subsequent behavior of mature individuals that it does in the subsequent behavior of individuals subjected to this experience early in life, or unless the differences between experimental and control subjects manipulated early in life are greater than those between experimental and control subjects manipulated at maturity, one can only conclude that prior experience exerts an influence on behavior. A majority of the studies cited below (as well as others in this area) have failed to use or mention this distinction.[3]

Early Experience and Emotionality

One of the earliest studies designed specifically to investigate the effects of "early" experience on subsequent emotional behavior was that of Hall and Whiteman (1951). Reacting against J. E. Anderson's (1948) statements contradicting the psychoanalytic emphasis on early trauma, these experimenters tested the hypothesis that "*subjecting the infant organism to intense stimulation will result in emotional instability in later life*" (Hall & Whiteman, 1951, p. 61). Beginning at 4 days of age, mice were subjected to four 2-min. periods of a loud, high-frequency bell. At 30 to 40 days of age, these mice and unstimulated controls were tested in an open-field situation. At 70 to 80 days of age, Stone's (1932) stovepipe test of emotionality was employed, and at 100 to 110 days of age the open-field test was repeated. On the basis of defecation, urination, and latency scores, found to be indicative of emotionality (E. E. Anderson, 1938; Hall, 1934; Hunt & Otis, 1953; Tryon, Tryon, & Kuznets, 1941b), it was concluded that animals subjected to intense stimulation during infancy are emotionally unstable in later life.

Although the differences on the first open-field test were significant, the authors themselves point out that on the stovepipe test only six animals could be described as having been influenced by the early experience. The remaining 15 experimental mice behaved normally. On the final open-field test the observed differences were not statistically significant, so that the results as a whole remain equivocal.

Griffiths and Stringer (1952) exposed groups of rats to a variety of noxious stimuli from birth to 21 days of age. A control group receiving "approximately the same treatment" (custodial care?) was not exposed to any of these stimuli. Beginning at 60 days of age, all groups were observed

[1] This research represents a portion of a dissertation submitted in partial fulfillment of the requirements for the Ph.D. degree at Cornell University, 1957. Thanks are due H. S. Liddell and G. W. Boguslavsky under whose direction this study was conducted.

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[3] For the reader interested in reviewing this literature it should be mentioned that studies published subsequent to the writing of this paper have taken into account these considerations.

in learning situations and in an open-field situation. No differences in learning ability or in emotionality were observed between any of the groups.

Infant mice were also exposed to noxious stimulation (electric shock) by Stanley and Monkman (1956). Here again, subsequent testing in an open field revealed no differences in the amount of defecation—or activity[4]—between animals receiving escapable shock, those receiving unescapable shock, and those placed into the apparatus without receiving shock.

Weininger (1956) has investigated the effects of "early" handling on subsequent emotional behavior. Animals handled for 10 min. each day for 21 days following weaning were found to be more active in an open-field situation than controls. The open field employed was 6 ft. in diameter and measured off into four concentric circles. "Gentled" animals also showed a greater incidence of entries into the innermost circles; nongentled animals tending to move about the outer walls of the apparatus (thigmotaxis), which is the usual behavior in this species.

Scott (1955) found no differences in the activity (in a Miller-Mowrer box) between animals which were handled, exposed to electric shock, or ignored for the 21 days following weaning. In this case the manipulation lasted only 3 min. per day. The discrepancy between Scott's results and Weininger's is probably not due to the difference in the amount of manipulation, however, since it has been demonstrated that animals handled for 3 min. per day for 30 days following weaning are less emotional than controls as measured by activity in an open field (Ader, 1957). Before testing in the open field, these animals were observed in an "emergence-from-the-cage" test,[5] the time required to emerge from the open home cage being indicative of emotionality or "timidity" (E. E. Anderson, 1938; Bindra, 1948; Hunt & Otis, 1955). During four such tests, only two of nine handled animals failed to leave their cage within a 15-min. period. Only one of eight nonhandled animals emerged from its cage, and this was on the last of the four tests. Again, handled animals prove to be the less emotional.

Results comparable to those described above were obtained by Hunt and Otis (1955). Although there were no differences in the amount of defecation in an open field, animals handled from the seventh through the twenty-first day of life displayed less emotional behavior, as measured by the number of animals emerging from a standard starting cage, than did controls given a restricted environment.

More recently Doolittle and Meade (1957) investigated the effects of handling rats at different periods of time. One group was given 10 min. of handling per day for three weeks following weaning while a second group was given the same manipulation beginning at 45 days of age. The testing of all groups began at 71 days of age. Whereas there was no evidence for the efficacy of early versus late handling, both handled groups, as measured by the amount of defecation which occurred during periodic weighing, were somewhat less emotional than controls. After depriving the animals, activity was recorded in a T maze in which they had previously received a 2-min. adaptation period. Nonmanipulated control animals showed the greatest amount of activity. This result is at odds with the results of previously cited studies (Ader, 1957; Weininger, 1956). A possible explanation lies in the fact that, as Doolittle reports, the handled groups were slightly heavier than the controls and consumed more food. This would lead one to suspect differential effects from the deprivation schedule which was imposed.

Of particular relevance to the present thesis are the discrepant results cited above. While there is general agreement that handling decreases emotional reactivity (Ader, 1957; Hunt & Otis, 1955; Weininger, 1956), there is not the same agreement between studies of the effects of noxious stimulation. Also, except in a single instance (Doolittle & Meade, 1957), the lack of appropriate control groups of mature animals prohibits any definitive statement concerning the effects of *early* experience on emotionality.

Early Experience and Avoidance Learning

Avoidance learning as a function of "early" experience has also been investigated, and in each instance the early experience has been electric shock. In the study by Stanley and Monkman (1956) one group of mice was exposed to shock that could be terminated by movement of the animal. A second group received shock that could neither be avoided nor escaped, and a third, placed into the apparatus, did not receive shock. As previously mentioned, no differences in emotionality were observed. In later avoidance training, with electric shock as the unconditioned stimulus, the group having received early experience with escapable shock was superior. The authors describe these results in terms of a positive transfer effect.

Chevalier and Levine (1955), and Levine, Chevalier, and Korchin (1956) also gave animals "early" experience with inescapable electric shock. In this study one group of rats was given daily shock from birth to 21 days of age. A second group was placed on the grid but did not receive shock, and a third group was completely ignored during this period. When given avoidance training at 60 days of age, the unmanipulated controls were inferior to the other two groups on all measures. There were no differences between the shocked and manipulated groups in the number of trials to criterion or the number of initial errors (trials to the first avoidance response). The total

[4] W. C. Stanley. Personal communication, Nov. 21, 1956.

[5] Described by the author in unpublished data.

number of errors, however, was greater for shocked animals than for the no-shock, handled group. One hypothesis suggested by these authors to account for this latter result is that shock in infancy may interfere directly with the cognitive functioning necessary for adequate performance in this situation. Such an interpretation, however, is at odds with the remainder of their data, since shocked and manipulated groups in the number of mals on the other measures and shocked animals are still superior to unmanipulated controls. An alternative hypothesis is that "early trauma leads to a heightened anxiety drive which persists into adulthood" (Levine et al., 1956, p. 490), and that the poorer performance of shocked animals is thus an effect of intense drive. Again, these animals show *superior* performance in contrast to unmanipulated controls, and the Stanley and Monkman results are evidence that such treatment can have a positive effect on subsequent performance.

The hypotheses of Chevalier, Levine, and Korchin are further contradicted by the results of the studies described below. In one (Steckle & O'Kelly, 1941), beginning at 20 days of age rats were given 35 days of experience with electric shock in that half of their cage where water was to be found. When tested later (at 70 days) in a situation where they had to cross an electrified grid to obtain water, the shocked group had a greater mean number of grid crossings as well as a greater percentage of animals that crossed the grid to water than did an untreated control group. According to the authors, " . . . the *early* experience with electric shock has produced an adaptation or a superior learned means of adjustment to the shock barrier situation" (p. 8, italics supplied), which has been carried over to the test situation.

It seems pertinent at this point to reiterate the fact that, unless one manipulates both young and old individuals in the same manner, one is not investigating *early* experiences but only the effects of *previous* experiences. That an individual's past experiences influence his present behaviors is well documented. That *early* experience is particularly influential remains to be conclusively demonstrated.

One further study of the effects of early experience on avoidance conditioning is especially worthy of mention because it is one of the few studies controlling for *early* experience. Baron, Brookshire, and Littman (1956) subjected rats to a strong electric shock for 6 min. on two consecutive days at either 20 days, 36 days, or at maturity. A control group was not shocked. Animals were later trained in either an escape or avoidance situation under either high or low shock as the unconditioned stimulus. In accordance with Doolittle and Meade's (1957) results on handling, and in contrast to the results of Hunt (1941) on hoarding behavior, Hymovitch (1952) and Hebb (1947) on problem solving, and Wolf (1943) on the inhibition of function in neurosis, all of whom found *early* experience to be crucial, these authors report that the animals subjected to the electric shock *at any time* prior to the learning situation were superior to controls in escape learning under both high and low shock and in avoidance learning under high shock. Although not significant, the results of avoidance learning under low shock were in the same direction. Traumatization, in infancy only, resulted in slower extinction of the escape learning under high shock. "The results are interpreted as: (1) substantiating the hypothesis that traumatization will affect subsequent learning *in which the traumatizing agent recurs;* (2) substantiating the hypothesis that effects of trauma are long lasting; (3) not strongly substantiating the hypothesis that traumatization at an early age has broader consequences than traumatization at maturity."[6]

Early Experience and Physiological Responses

In studies designed specifically to determine the effects of "early" experience on growth characteristics, Weininger and his associates (McClelland, 1956; Weininger, 1954, 1956; Weininger, McClelland, & Arima, 1954) observed that handled animals weighed significantly more than unmanipulated controls. With but one exception (Scott, 1955), similar findings have been reported by other investigators (Bernstein, 1952; Ruegamer, Bernstein, & Benjamin, 1954).

Griffiths and Stringer (1952) report normal growth curves for groups of animals exposed to a variety of noxious stimuli during early life. Such groups did not differ from control animals. In contrast to these results, two of the groups manipulated by Herrington and Nelbach (1942) have relevance here. These authors found that by 210 days of age a group of "disturbed" animals (those exposed to "intermittent bell ringing, air blasts, and cage vibration once each hour") showed a greater body weight than controls (those maintained in a room with a temperatue of 83° F.). It is not known, however, at what age this treatment was begun nor for how long it lasted.

Weininger (1953) has also found that the mortality rate in the rat is affected by "early" experience. Adult animals were subjected first to 60 hr. without food or water which was then continued until 120 hr. had elapsed. Under this stress all nongentled animals eventually succumbed. Those animals handled for 10 min. per day during the 21 days following weaning survived. These results confirm the earlier findings of Hammett (1921, 1922) who observed a decreased mortality rate in previously tamed animals subjected to an operation for removal of the parathyroid gland.

Again to the contrary, Scott (1955) found no differences in the adult mortality rate of handled animals, those exposed to electric shock, and ani-

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[6] A. Baron. Personal communication, Oct. 8, 1956 (italics supplied).

mals ignored throughout infancy. The stress situation imposed was the injection of 100 mg./100 gm. body weight of thiourea. According to Bernstein (1956), such a dosage would be extreme and one may infer that no manipulation could prevent death from such a dosage. Furthermore, Scott administered these injections to mature animals (136 days). Bernstein (1956), referring to a study as yet unpublished, obtained contradictory results with young animals, and it has been reported elsewhere (Mackenzie & Mackenzie, 1943) that the susceptibility of the rat to the toxic effects of thiourea increases with age.

Of particular relevance to the present thesis is the work of Noble (1943) and Noble and Collip (1942). These investigators have devised a method for producing graded amounts of trauma in small animals. "The animal, after taping of the paws, is placed in a circular drum which has two projections on the side. During rotation of the drum the animal is alternately carried a short distance up the side on the projection and then dropped. The amount of trauma, therefore, is directly related to the number of turns of the drum, and is reflected on the mortality curve" (Noble, 1943, p. 346). That is, the greater the number of turns the greater the trauma, and the greater the trauma the sooner animals die. Subjecting animals to 1000 turns results in mortality in 98% of the cases tested. Characteristically, death ensues following termination of the trauma rather than during the tumbling. Repeated experimentation has shown that rats may be made resistant to this trauma by subjecting them to increasing amounts of sublethal tumbling in the drum. Within a period of 12–14 days, an animal may be raised from 200 to 1000 turns and survive. Being subjected to 1000 turns every week thereafter still fails to cause death. It has not yet been determined if animals made resistant to trauma in the Noble-Collip drum maintain this resistance when exposed to other forms of stress.

Griswold and Gray (1956), having observed that the administration of various autonomic drugs prior to stress serves to reduce mortality, conclude that a diminution of activity in part or all of the autonomic nervous system serves to protect an animal from stress. Tumbling in the Noble-Collip drum elicits the classical emergency pattern of responses and, "It is conceivable that such repetition of sympathetic discharge could result in a gradual alteration in the character of the process so that on subsequent exposure to an ordinarily lethal challenge, the sympathetic system reacts with less violence, thereby causing the survival of the animal. Alternatively, it is possible that the effector organs activated by the autonomic system may become less responsive to a given strength of discharge after having been repeatedly stimulated" (Griswold & Gray, 1956, p. 1).

Based on this reasoning, Griswold and Gray chose electroconvulsive shock (ECS) as the means by which autonomic stimulation could be achieved. Following a series of ECS treatments, rats were subjected to tumbling trauma in the Noble-Collip drum. It was found that one ECS for 4 days or four ECS in a space of 1 or 2 days resulted in an increased resistance to the subsequent trauma. Ten and 20 ECS's produced only a small additional increase in resistance.

After observing his groups in the behavioral situations previously discussed, Weininger (1956) and Weininger et al. (1954) subjected handled and nonhandled animals to a severe stress situation. Animals were immobilized in gauze and adhesive tape and remained so for 48 hr. without food or water. At the end of this period they were sacrificed and autopsies were carried out. Nongentled animals showed greater damage and distension of blood vessels of the heart, and suffered more bleeding points throughout the gastrointestinal system. There were no differences in the weights of the liver, kidneys, or pancreas, but the adrenals were heavier in the nongentled animals. The organ weights of nonstressed handled and nonhandled animals did not differ.

In attempting to account for these results, Bovard (1954) has suggested that a reduction in sympathetic activity and decreased ACTH output from the pituitary, effected by a change in hypothalamic functioning, accounts for the hypo-activity of the adrenal glands of gentled animals. That an increase in resistance is effected by a decrease in autonomic activity was also hypothesized by Griswold and Gray (1956).

While similar to Weininger's handled animals in the direction of the body weight difference, Herrington and Nelbach's (1942) "disturbed" animals differed from "gentled" animals in that autopsy showed the adrenal glands to be *heavier* than those of the control group.

The relationship between the adrenal glands and reactions to stress is well documented (Selye, 1950), adrenal size being indicative of the gland's capacity for sustained secretion (Hartman & Brownell, 1949). On a behavioral level, adrenal size has been found to be positively correlated with emotionality (Hall, 1939; Yeakel & Rhoades, 1941), as measured by the open-field test.

The Hypothesis

The present thesis derives from the writer's interpretation of some of the research findings discussed above. The present section, then, is concerned with an attempt to organize some seemingly discrepant results with regard to the effects of early experience on subsequent emotional behavior.

Concerning the effects of specific types of "early" experience on subsequent emotionality in situations which are not specific to

the early experience, we have seen that there is general agreement that handling decreases emotional reactivity (Ader, 1957; Hunt & Otis, 1955; Weininger, 1954). There is not the same agreement between studies of the effects of noxious stimulation during early life. It has been variously reported that "emotionalized" animals are emotionally unstable (Hall & Whiteman, 1951), do not differ from controls (Griffiths & Stringer, 1952; Stanley & Monkman, 1956), and are less emotional than control animals (Ader, 1957).

The research by Weininger and his associates (McClelland, 1956; Weininger, 1954, 1956; Weininger et al., 1954) has shown that handling, as a variable experienced in early life, is capable of altering the rate of growth, structure and behavior of the rat. Animals thus treated show less emotional behavior and appear more capable of withstanding severe stress. These findings have been supported both physiologically (Hammett, 1921, 1922; Ruegamer et al., 1954; Ruegamer & Silverman, 1956) and behaviorally (Ader, 1957; Bernstein, 1952; Karn & Porter, 1946).

The reference to these animals as "gentled" (Weininger, 1956) connotes a personality trait, which, although operationally defined, suggests itself as a correlate of the physical and behavioral characteristics observed. While such a relationship may be the case, such a conclusion would be premature at present, and recent evidence on the effects of other types of previous experience on emotionality (Ader, 1957) suggests that handling is not the only variable that can effect a heightened reaction threshold to emotion-provoking situations. In this study, one group of animals was handled for 3 min. per day for 30 days following weaning. A second group was subjected to an emotion-provoking situation equal in distribution and duration to the handling procedure. A control group was completely ignored during this period. As measured by an open-field test, the behavior of mature animals previously exposed to an emotion-provoking stimulus other than handling and those subjected to a "gentling" procedure during early life did not differ significantly. Both experimental groups, reacting in much the same manner, evidenced significantly more activity than unmanipulated control animals. Although not significant, a similar trend was noted on an elevated Y maze. It appears, then, that a distributed emotion-provoking experience, as well as handling, is capable of raising, temporarily at least, the threshold for emotional reactivity.

The following interpretations are offered with regard to the conflicting results of previous studies. Using an open field, Stanley and Monkman (1956) found no differences between the defecation and activity of groups of animals given early experience with electric shock and controls which were *picked up and placed into the apparatus* without receiving shock. Such a control group would be comparable to my handled animals and not expected, in light of the above findings, to differ from "emotionalized" animals. The same interpretation might also account for the results of Griffiths and Stringer (1952) whose control animals "received approximately the same treatment as the experimentals except that they were not exposed to the types of intense stimulation mentioned" (p. 302).

Support for the inadequacy of these control groups comes from a study wherein unmanipulated controls were compared with a group receiving electric shock and one placed on the grid without shock (Chevalier & Levine, 1955). Ignored animals proved inferior when given avoidance training at 60 days of age.

The results of the Hall and Whiteman (1951) study, which concluded that intense stimulation in infancy results in emotional instability, may be due to a number of variables. The stimulus situation used was exactly like that employed in eliciting audiogenic seizures (Witt & Hall, 1949), and the strain of mice used was previously shown to have a high proportion of seizure-susceptible animals (Hall, 1947). Moreover, as has been pointed out (Beach & Jaynes, 1954), the open field situation in which these animals were later tested was the same as that in which the early experience occurred.

Each of the variables discussed above (including handling) represents a situation foreign to the accustomed laboratory environment of the animal. As any researcher with animal experience will testify, the rat initially resists attempts at being handled, and Tryon et al. (1941a, 1941b) has even used the handling situation as one reliably eliciting emotional behavior.

While the behavior of handled animals and those subjected to an emotion-provoking situation in early life does not differ on certain tests (Ader, 1957) it would not be justified to define handling as an emotion-provoking stimulus. In the present thesis the position is taken, however, that both the handling regime and emotion-provoking situation constitute, initially at least, a change from the basal level of stimulation. It is hypothesized, then, that handling or any emotion-provoking stimulation of a nontraumatic nature and distributed throughout the *early* life of an individual is capable of raising the threshold for emotional reactivity to subsequent, qualitatively different emotion-provoking situations. Although on different levels, one may note the similarity of this hypothesis to that advanced by Griswold and Gray (1956).

The fact that the particular type of "early" experience in previous studies remained the same on successive occasions suggests that learning may have been involved. The superior learning performance demonstrated by handled animals (Bernstein, 1952; Karn & Porter, 1946) may simply be due to their having adapted to the handling involved in the subsequent experimental procedure. And superior performance in avoidance conditioning with shock as the unconditioned stimulus appears to be due to early experience with electric shock. If adaptation is a significant variable, what might be the effect of qualitatively different experiences during early life, none of which were repeated often enough to allow for any specific adaptive response?

Besides the lesser degree of emotional behavior displayed by handled and "emotionalized" animals (Ader, 1957; Weininger, 1956), handled animals also show less organic damage under severe stress conditions (Weininger, 1954, 1956). One might ask whether animals subjected to emotion-provoking stimulation during infancy would demonstrate the same resistance, and, if so, whether there were qualitative and/or quantitative differences in the physiological mechanisms mediating such resistance. That such differences may exist is suggested by Herrington and Nelbach's (1942) study wherein "disturbed" animals showed an increase in both body weight and weight of the adrenal glands over control animals; the former being characteristic of "gentled" and the latter of nongentled animals (Weininger, 1956).

The purpose of the present research, then, is (a) to test the hypothesis that both handling and emotion-provoking stimulation of a nontraumatic nature, if distributed throughout early life (as opposed to manipulation at maturity), are capable of raising the threshold for emotional reactivity to subsequent emotion-provoking situation, and (b) to investigate the influence of handling and various types of emotion-provoking stimulation during early life on subsequent resistance to a prolonged stress situation which, if continued, would result in death.

METHOD

The rats used in this investigation were bred in the colony of the Department of Psychology at Cornell. At weaning (22 days of age) 104 albino rats from 11 litters were divided into 10 groups of 10 or 11 animals. Groups were equated for sex and body weight, and, insofar as was possible, at least one animal from each litter went into each group. Once divided, groups were randomly assigned to one of 10 conditions. Five of these groups were to be manipulated during early life (Part A of the experiment) and the remaining five groups, representing the same five conditions, were to be manipulated during maturity (Part B of the experiment). The inclusion of comparable groups of mature animals is essential if one is concerned with the effects of *early* as opposed to *previous* experiences on a given variable.

All animals were maintained in a well illuminated, temperature-controlled room. Four to six rats were housed to a wire mesh cage measuring either 12 × 14 × 8 in. or 12 × 10 × 8 in. An ad libitum food and water schedule was maintained until the final stress measures were taken.

On the day following weaning the differential treatment of animals of Part A was begun and it adhered to the following program for 30 successive days. Weekly weight measures were taken throughout the experiment.

Group H ($N = 10$) was handled for approximately 3 to 4 min. per day in a random, nonstandardized manner. Animals were stroked, scratched, and allowed to wander over the experimenter's hands and arms.

Animals of Group E_D ($N = 10$) were lifted by the tail with a large forceps and placed individually into a cylindrical wire mesh cage measuring 5 in. in diameter and 8 in. in length. These dimensions provided ample room for the largest animal to move about. The cage was suspended from an overhanging beam by two ropes 21 in. long. In this position, animal and cage were lifted and then allowed to swing freely. This procedure was repeated four times each day, a period equal in time to that of the handling procedure.

Group E_V ($N = 10$) was exposed to a variety of emotion-provoking stimuli. These included (*a*) swinging in the above-mentioned cage, (*b*) being thrown into the air through one complete somersault in this same cage, (*c*) being placed under a gallon-sized cardboard liquid container into which small air holes had been punched, (*d*) being rolled across the floor in this same container, (*e*) having their tails pinched with the forceps, (*f*) vigorous rattling of their cage, (*g*) exposure to electric shock, and (*h*) being placed into a metal cooking pot (12.5 in. in diameter and 8 in. high) which *E* covered and banged upon with a stick.

The above situations were chosen from a longer list of noxious stimuli as being least likely to cause physical damage to the animal. Some of these procedures have been employed in previous studies (Griffiths & Stringer, 1952; Herrington & Nelbach, 1942; Higginson, 1930; Humphrey & Marcuse, 1939; Scott, 1955). When applicable, these stimuli were presented for a period equal to that involved in manipulation of the preceding groups. Being tossed into the air in the restricting cage was repeated 10 times on one day. The electric shock, adjusted for each animal to that voltage required to elicit a moderate squeal, was presented intermittently over a 3-min. period, on the grid of a Skinner box. Situations *e* and *f* were carried out while all the animals were together in their living cage. The remaining stimuli were presented to each animal individually. Whenever possible, animals of this group were manipulated by means of a large forceps, or, if by hand, were picked up by the tail. Only one of these stimulus situations occurred on a given day. The order of presentation was random.

Group E_M ($N = 10$) was exposed to the same emotion-provoking stimuli as Group E_V; however, in this case they were all presented on the same evening. The situations immediately followed upon one another, and might well be described as "traumatic." This massed experience occurred at a mean age of 35 days for animals of Part A and at a mean age of 148 days for animals of Part B.

Group C ($N = 11$) served as controls, experiencing no manipulation by the experimenter other than the proximity associated with feeding, the cleaning of cages, and being weighed weekly. Feeding necessitated opening and closing cages each day. Cleaning involved *E*'s being active in the vicinity of the cages every second or third day.

When the animals reached a mean age of 68 days, each cage of rats, in turn, was placed on a table between two other covered cages of equal size. The experimenter stood at a distance and recorded the time required by each animal to emerge from its living cage. The same procedure was repeated at 78 days of age.

At a mean age of 69 days, animals were introduced singly into an open-field situation for 1 min. on 5 successive days. The apparatus was 5 ft. in diameter with 2-ft.-high sheet metal walls. The unpainted Masonite floor was chalked off into four concentric circles and 7.5-in. squares (Weininger, 1956). The field was placed on the floor of a well illuminated room just to the side of a series of fluorescent ceiling lights.

An animal was placed in a square next to the wall and his subsequent activity recorded by a tracing of his path on a scaled diagram of the apparatus. Movement into an adjacent square was recorded when the animal moved all four paws across the boundary line. The same criterion held for movement from one to another of the concentric circles. The total number of squares traversed and movements with respect to the concentric circles were noted.

At a mean age of 75 and 76 days, animals were placed onto one end of an elevated Y maze (Montgomery, 1953). Measuring from the midline of the maze, the 32-in. arms came together within a circle 15 in. in diameter. Measuring from the outer edge, the arms were 25.5 in. long, 7.25 in. wide, with 1-in. high walls. The entire maze was painted flat black. Each arm was chalked off into two 10-in. units and one 12-in. unit reaching into the center. The apparatus rested on three piano stools at a height 3 ft. from the floor.

Half the animals of each group were run on one day. A trial began when the animal moved four paws into the unit adjoining the one into which he was placed. Once started, the animal's position was determined by the unit in which his front paws rested. Recorded were the time required to move from the starting position and the total number of units traversed during each of three successive minutes.

At a mean age of 87 days, 7 animals from each group were weighed and then subjected to 48 hr. of immobilization plus food and water deprivation in a somewhat colder than usual experimental room (20° C.).

Immobilization was accomplished by means of ¼-in., 27-gauge wire mesh. A piece approximately 8 in. square was first rolled into a funnel and four

or five longitudinal cuts were made at each end. Those at the apex were folded in, closing off the wire into a truncated cone. Those at the base were temporarily bent outwards. A heavy rubber band was placed around the middle. Just past the middle, toward the base, a slit, approximately ½ in. wide was cut. This slit extended around ⅓ to ½ the diameter of the cone at that point. Through this slit a 1-ft.-long insulated wire was inserted so that the ends were on the outside and the middle hugged the circumference of the cone. The cone and wire were held in the left hand and the experimental animal was literally "run" into the wire cage, whereupon *E* closed off the base of the cone locking the animal in place. An excess of room for a given animal was eliminated by pinching in the wire at appropriate places. This procedure allowed for rapid immobilization and prohibited escape.

The electrical wire extending from the immobilization cage was actually two wires joined in the middle by a thin rubber tube packed with powdered graphite. This section partly surrounded the middle of the animal's body. The expansion and contraction of the animal's body at every breath changed the diameter of the graphite-filled tube, thereby changing the current flow through the wire. This change was amplified and caused a kymograph pen to chart the pattern of respiration on a roll of paper moving at a fixed number of revolutions per minute.[7] To facilitate the reading of respiration rate, the kymograph pen also closed a leaf switch activating an automatic cumulative counter.

Samples of the respiration of animals in stress were taken at 15-min. intervals during the first hour and at 8-hr. intervals (plus or minus 15 min.) thereafter. The availability of only one amplifier and pen as well as the time required in the later sacrificing of animals necessitated placing the animals in stress at hourly intervals. Two to five animals were immobilized during any one morning, afternoon, or evening period.

Once immobilized, an animal was placed, stomach down, upon a long Masonite board (9 × 32 in.) in a small experimental room opposite that in which the recording devices were located. Screws protruding from the board kept the immobilization cage from rolling over. Each "slot" had its own "jacks" into which the respiration leads could be inserted. All of these were wired into a separate control panel so that the experimenter could change the animal being recorded without having to enter the experimental room. Occasionally, certain 8-hr. records for a given animal were omitted for practical reasons; at other times mechanical failures contributed to the smaller *N* representing the respiration measure after a given number of hours in stress.

At the end of the 48-hr. immobilization period, animals were removed from the wire mesh and weighed. One cc. of nembutal (approximately 6 mg./kg. of body weight) was injected intraperitoneally, and when the animal was completely anesthetized its throat was cut. The heart, liver, kidneys, spleen and adrenal glands were removed, placed into a 10% solution of formaldehyde, and weighed during a period one to two weeks later. A separate, coded jar was used for each animal so that *E* had no knowledge of the group to which an animal belonged at the time of weighing.

Three randomly chosen animals from each group (four in the case of Group C) served as stress controls. These animals were sacrificed and autopsied without having been subjected to the immobilization procedure.

Animals in Part B of the experiment were subjected to the same conditions as described above beginning at a mean age of 136 days. Their early experience was the same as that described for the control group of Part A.

On the basis of certain incidental observations and a perusal of the stress data of Part A, certain additional procedures were employed. Hourly respiration measures were taken during the first 8 hr. of immobilization. Immediately upon sacrificing the animal, samples of blood were drawn from the heart and the procedure outlined by Loewe, Rosenblatt, and Hirsch (1946) was employed to determine the time required for clotting to occur. Finally, a human oral thermometer was used to take aperiodic samples of rectal temperature during the 48-hr. period of immobilization.

An outline of the experimental procedure appears in Table 1.

Results

Body Weight

Following Scott's (1955) suggestion, the data from the weekly weight measurements were analyzed in terms of the percent increase in body weight rather than the absolute weight values of each group. By converting the data in this manner, one compensated for any possible tendency on the part of a given group to be initially heavier. The growth curves for animals of Part A were not amenable to clear graphic presentation. The five curves were virtually superimposed upon one another. For animals of Part B, the mean percentage increase in body weight over the initial body

[7] This method of obtaining respiration measures was modeled after that devised by A. U. Moore who developed the technique for large animals at the Cornell Behavior Farm. The author is indebted to Dr. Moore for the use of his equipment and his assistance in setting up the present apparatus.

TABLE 1

OUTLINE OF EXPERIMENTAL PROCEDURE

Age (in days)		Group				
Part A	Part B	H	E_D	E_V	E_M	C
22	22	Weaning (all groups)				
23–53	136–166	Handling	Single, distributed emotion-provoking situation	Variety of emotion-provoking situations, distributed	Variety of emotion-provoking situations, massed (at 35 or 148 days of age)	No manipulation
54–67	167–180	No manipulation				
68	181	Emergence from cage (I)				
69–73	182–186	Open field				
74	187	No manipulation				
75, 76	188, 189	Y Maze				
77	190	No manipulation				
78	191	Emergence from cage (II)				
79–86	192–199	No manipulation				
87	200	Stress NS*				
		Sacrifice all animals				

* Stress control animals underwent no manipulation during this period.

weight has been plotted in Fig. 1. While young animals doubled their body weight in the two weeks of manipulation following weaning, animals of Part B, beginning manipulation at 136 days of age, did not gain 12% of their premanipulation weight throughout the entire period of measurement. Despite this difference in the magnitude of the values, and in order to uncover any interaction effect should one exist, one analysis of variance was applied to all of the data (Table A).[8] As was to be expected, the difference between the weight gains of early and late manipulated animals is significant.

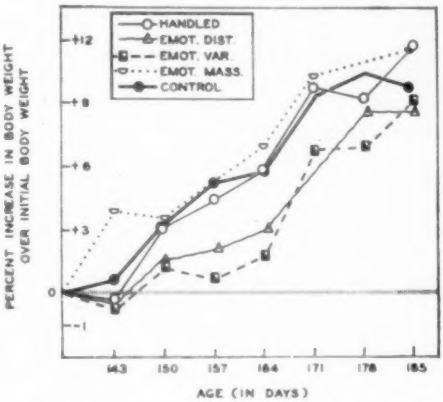

FIG. 1. Mean percentage increase in body weight over initial body weight for animals manipulated late in life.

The F test did not reveal significant weight differences as a function of the differential treatment of the various groups. It is of interest, however, that at the beginning of the manipulation of the late groups, both handled animals and those exposed to

[8] Tables summarizing the analysis of variance for this and subsequent data have been designated alphabetically and have been deposited with the American Documentation Institute. Order Document No. 5819 from ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C., remitting in advance $1.75 for microfilm or $2.50 for photocopies. Make checks payable to Chief, Photoduplication Service, Library of Congress.

TABLE 2
NUMBER OF SECONDS REQUIRED FOR EMERGENCE FROM CAGE
(TEST I)

Period	Group H		Group E_D		Group E_V		Group E_M		Group C		Combined Mean
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	
Early	10	303.5	10	332.5	10	449.4	10	479.8	11	472.3	407.5
Late	9	521.6	9	711.9	9	670.2	8	696.5	9	458.5	611.74
Combined		412.5		522.2		559.8		588.1		465.4	

distributed emotion-provoking stimulation showed a loss in body weight. The remaining two groups which experienced no manipulation at this time (C and E_M) showed the expected increase in weight. During the week in which Group E_M was subjected to the massed emotion-provoking stimulation (148 days) it, too, showed a decrease in weight. While consistent with the present hypothesis, not too much emphasis should be placed upon such data because of the seemingly random fluctuations in weight shown by all of the other groups at some time during the 7-week period.

Emergence From Cage

The mean number of seconds required by all groups in emerging from their cages is given in Tables 2 and 3. A summary of the analysis of variance for the first emergence-from-cage test is given in Table B. Due to the unequal N in this and subsequent data the procedure suggested by Snedecor (1946) was followed. The value of F was determined using group means and a corrected within-group variance calculated on the basis of the size of each group.

The analysis showed only the interaction between the type of experience and the time at which it occurred (early or late) to be significant ($F = 28.79$, $df = 4$, $p < .01$). In order to determine which groups were responsible for this significant F, independent t tests were run between early and late animals for the various experimental conditions. While no difference was demonstrated to exist between early and late control animals, all animals subjected to manipulation late in life required significantly more time before leaving their cages than their early manipulated counterparts ($p < .01$ in all cases).

Bartlett's test for homogeneity of variance was applied to all data before performing an analysis of variance. Unless otherwise specified, the value of chi square was not significant. In the case of the second emergence-from-cage test, Bartlett's test revealed heterogeneity of variance ($\chi^2 = 22.02$). A square-root transformation was applied and served to normalize the data as indicated by reapplication of the Bartlett test. A summary of the analysis of variance on the transformed data appears in Table C. Here again there

TABLE 3
NUMBER OF SECONDS REQUIRED FOR EMERGENCE FROM CAGE
(TEST II)

Period	Group H		Group E_D		Group E_V		Group E_M		Group C		Combined Mean
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	
Early	10	449.0	10	159.7	10	124.7	10	334.7	11	220.4	257.7
Late	9	605.5	8	494.6	9	505.5	7	549.0	8	501.0	531.12
Combined		527.2		327.1		315.1		441.8		360.7	

TABLE 4

NUMBER OF SQUARES TRAVERSED PER 5 TRIALS IN THE OPEN FIELD

Period	Group H		Group E_D		Group E_V		Group E_M		Group C		Combined Mean
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	
Early	10	34.60	10	27.34	10	33.60	10	27.90	11	26.67	30.02
Late	9	20.08	9	18.99	9	13.82	8	12.37	9	16.64	16.38
Combined		27.34		23.16		23.71		20.13		21.65	

were no differences in the time required for animals to emerge from their cages as a function of the type of manipulation experienced, and unlike Test I, no interaction effect was demonstrated. Animals manipulated later in life, however, do require more time in emerging from the cage ($F = 21.35$, $df = 1$, $p < .01$). The mean number of seconds required by early manipulated animals was 257.7 as opposed to 531.1 sec. for animals manipulated later in life. Although not significant in the case of control animals, this same result was observed in the case of manipulated groups in the first test.

Open Field

Activity in the open field in terms of the mean number of squares traversed for both early and late groups is shown in Table 4, and Table D summarizes the analysis of variance for the activity measure. The only significant value ($F = 25.61$, $df = 1$, $p < .01$) occurs between the groups of animals manipulated early (with an over-all mean of 30.02 squares traversed) and those groups manipulated later in life (with an over-all mean of 16.38).

The data with respect to the concentric circles of the open field are given in Table E. In the analysis by Weininger (1956), the percentage of times that animals were in each concentric circle of the field was plotted. The present data are plotted in terms of the number of entries made by the animals of each group into Circles 2, 3, and 4 of the open field (Fig. 2). This latter mode of presentation was chosen because of the rat's tendency to remain close to the walls and avoid the lighter, open center of any given field. The great majority of activity in the open field occurred in the outermost circle (Circle 1). An animal entering inner circles of the field would invariably return within a few seconds to the outermost circle, usually after having "passed through" rather than having "wandered about" the inner areas. In returning to the outer circle, the animal must again pass through inner circles of the field, thereby increasing differentially the amount of activity in Circles 2, 3 and 4, and in that order. It is felt that a somewhat more accurate account of the distance away from

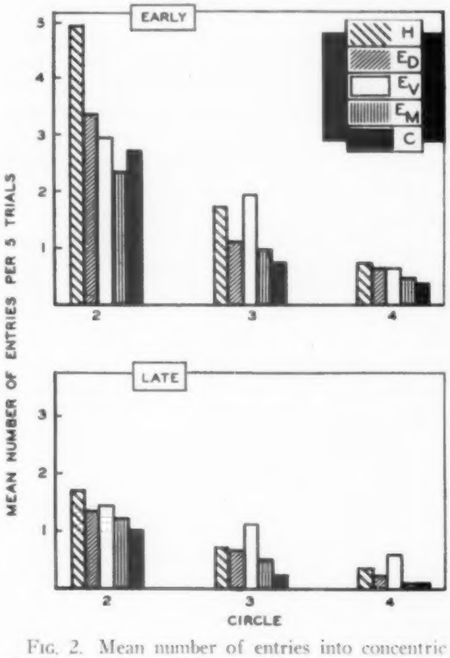

FIG. 2. Mean number of entries into concentric Circles 2, 3, and 4 of the open field.

the walls of the apparatus (as a measure of "emotionality") is achieved by counting only the number of forward-going entries into the inner circles.

For concentric Circles 2 and 3, the analyses of variance are summarized in Tables F and G. In view of the many zero scores, 0.5 was added to each score and the square root of this value was taken. The analyses were performed on the transformed data.

Animals tested early in life show significantly more entries into Circles 2 and 3 than animals tested at maturity ($F = 15.00$ and $F = 41.82$, $df = 1$, $p < .01$ in both cases). No interaction effect was demonstrated in either of these circles. For Circle 2, the value of F revealed no differences resulting from differential experience, while the value of F (3.64, $df = 4$) for the variable of experience in Circle 3 was significant at the .01 level.

In order to determine which of the differences among the various types of experience may be considered significant and which may not, the *new multiple range test* devised by Duncan (1955) was employed. Because of the differences in N's and standard errors (although negligible), and in order to be on the conservative side, the larger standard error was used in calculating the difference between any two given groups. A summary of this analysis (also performed on the transformed data) is given in Table 5.

From the table it can be seen that there is no difference between Groups C and E_M. The mean value for Group E_D is significantly greater than that for either C or E_M, and, although Groups H and E_V do not differ, both show significantly more entries into concentric Circle 3 than do all the other groups.

TABLE 5

Standard Error of the Means, Means, and the Significance of the Difference Between Means for the Number of Entries Into Concentric Circle 3 of the Open Field as Determined by the New Multiple Range Test (Transformed Data)

	Group				
	C	E_M	E_D	H	E_V
$SE_{\bar{x}}$	.0170	.0185	.0180	.0180	.0180
Mean	1.00	1.01	1.10	1.19	1.25

Note.—Any two means that are *not underscored* by the same line are significantly different at the .05 level of confidence. Means underscored by the same line are not significantly different.

TABLE 6

Defecation Measures Over 5 Trials in the Open Field for Animals of Part B

Measure	Group				
	H ($N=9$)	E_D ($N=9$)	E_V ($N=9$)	E_M ($N=8$)	C ($N=9$)
Mean	.09	.18	1.28	1.57	.75
No. animals defecating	1	1	4	7	5
% animals defecating	11.1	11.1	44.4	87.5	55.5

With regard to the innermost circle, no statistical tests were employed since the majority of scores were zero. That is, very few animals in any group, whether tested early or late, entered Circle 4. Suffice it to point out that the pattern set down for Circles 2 and 3 (Groups H, E_D, and E_V having greater mean values than Groups E_M and C) is repeated for Circle 4 (Fig. 2).

Defecation was also studied as a variable in the open-field situation. In the case of those groups manipulated in early life, no more than one animal in each group defecated. Animals manipulated later in life showed a sufficient amount of defecation to warrant statistical analysis. Defecation measures for animals of Part B of the experiment are given in Table 6. Because of the preponderance of zero scores and the rather wide range of scores it was felt that any assumption about the normality of the data would be unrealistic. Since defecation data from Part A was not being analyzed concomitantly, the use of a nonparametric technique in the present instance did not involve the loss of any interaction effect. For these reasons the data were not transformed, and the Kruskal-Wallis one-way analysis of variance (Kruskal, 1952) was employed. The obtained value of H (8.842) permits rejection of the null hypothesis at the .069 level of confidence. That is, these

TABLE 7
LATENCY IN Y MAZE
(In Seconds)

Period	Group H		Group E_D		Group E_V		Group E_M		Group C		Combined Mean
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	
Early	9	38.1	9	42.8	10	15.3	10	21.5	11	19.0	27.3
Late	9	38.1	7	58.3	8	147.8	7	99.0	7	143.6	97.4
Combined		38.1		50.5		81.5		60.2		81.3	

results could have been obtained by chance about 7 times in 100.

Using the Mann-Whitney (1947) U test and the extended tables given by Siegel (1956), the following independent comparisons consonant with the present hypothesis were made:

Comparing Group E_M with C, the critical value for U at the .05 level is 15. The obtained value of U (22.5) does not allow rejection of the null hypothesis, the difference between these groups being no greater than would be expected on the basis of chance alone.

Comparing Group E_D with Group E_V, the critical value for U at the .05 level is 17. Here again, the observed value of U (26.0) does not allow rejection of the null hypothesis.

Comparing Group H with Groups E_D and E_V, the critical value for U at the .05 level is 99. The observed value of U is 65.0, indicating that Groups E_D and E_V, combined, excrete significantly more fecal boluses in the open field than do handled animals.

Comparison of Groups H, E_D, and E_V as a whole with Groups E_M and C (pooled) provides a population large enough so that the distribution of U closely approximates that of a normal distribution. For this comparison $Z = 3.77$ ($p < .01$). Nonmanipulated control animals and those animals subjected to the massed emotion-provoking stimulation, combined, show more defecation in the open field than the remaining three groups taken together.

Y *Maze*

As a correction for the obtained heterogeneity of variance ($\chi^2 = 161.1$), a square-root transformation was applied to the data of the measure of latency in the Y maze. The mean latencies in the original data appear in Table 7. A summary of the analysis of variance on the normalized, transformed data is given in Table H.

The only value of F which is significant at better than the .05 level of confidence occurs between the groups of animals manipulated early (with a mean of 27.3 sec.) and those manipulated later in life (with a mean of 97.4 sec.) ($F = 9.64$, $df = 1$, $p < .01$).

Activity in the Y maze, measured by the number of units traversed, is plotted in Fig. 3 and 4. A summary of the analysis of variance appears in Table I. In this case the variable of experience (the various types of manipulation) yields a significant

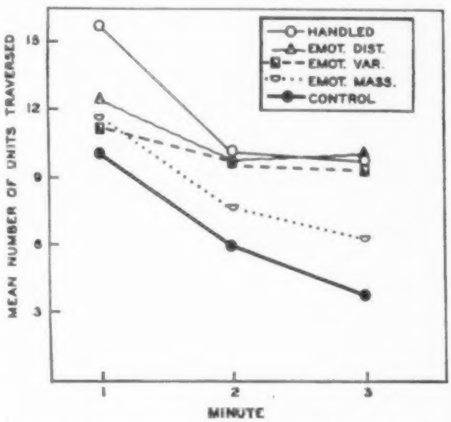

FIG. 3. Activity per minute in the Y maze for all groups of Part A.

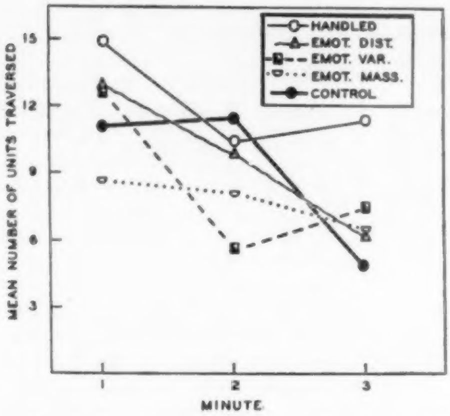

FIG. 4. Activity per minute in the Y maze for all groups of Part B.

value ($F = 3.22$, $df = 4$, $p < .05$). As in the case of concentric Circle 3 of the open field, the ***multiple range test*** was used to determine which of the differences among the various types of experience may be considered significant at a satisfactory level of confidence (.05). A summary of this analysis is given in Table 8.

From the table it can be seen that, while no difference has been demonstrated between Groups C and E_M, both show significantly less activity than handled animals. Group C is also significantly less active than Group E_D. Differences in activity were not demonstrated between any other combination of groups at the .05 level of confidence.

As was the case in the open field, animals manipulated early in life did not defecate in the Y maze in sufficient quantity or in number of animals defecating to warrant statistical analysis. Although the amount of defecation was not great for animals manipulated later in life, the data were analyzed in the same way as for the open field. The Kruskal-Wallis one-way analysis of variance was employed. The obtained H (0.35) failed to approach a satisfactory level of confidence.

TABLE 8

STANDARD ERROR OF THE MEANS, MEANS, AND THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS FOR ACTIVITY IN THE Y-MAZE AS DETERMINED BY THE MULTIPLE RANGE TEST

	Group				
	C	E_M	E_V	E_D	H
$SE_{\bar{x}}$	.969	1.032	.942	.999	1.032
Mean	7.71	8.33	9.42	10.86	12.01

Note.—Any two means that are not underscored by the same line are significantly different at the .05 level of confidence. Means underscored by the same line are not significantly different.

Respiration Rate Under Stress

The first sample of respiration rate was taken as soon as an animal was immobilized. For animals of Part A, samples were taken during the first hour of stress, at hourly intervals during the first 8 hr. of stress, and at 8-hr. intervals thereafter. In this latter case, additional samples were taken whenever time allowed, although it was the first 8 hr. which were concentrated upon. These additional measures were taken in order to determine if the changes in respiration over the 48-hr. period of stress were similar in pattern to changes characteristic of Selye's (1950) ***general adaptation syndrome***, as was indicated by the similar form of the respiration patterns for a few animals of Part A.

In Table 9 the mean number of breaths per minute is recorded for the initial measure and the period just before being removed from the immobilizing wire. The analyses of variance (Tables J and K) indicated no differences to exist between any groups.

The data from respiration rates were not readily amenable to either concise presentation or statistical analysis. In many cases mechanical difficulties resulted in a smaller N representing the rate of respiration after a given number of hours in stress. The number of animals for whom a complete record was obtained was relatively small. Under these circumstances the graphic representation of the mean respiration rate through the 48 hr. of stress would hardly be representative. Moreover, even if records were available for the total N at each period of measurement, the variability in the magnitude and the time relations of the

TABLE 9

INITIAL AND FINAL RESPIRATION RATES (PER MIN.) UNDER STRESS

	Group H *N*	Group H Mean	Group E_D *N*	Group E_D Mean	Group E_V *N*	Group E_V Mean	Group E_M *N*	Group E_M Mean	Group C *N*	Group C Mean	Comb.
					Early						
Initial Respiration Rate	7	111.0	6	107.5	5	79.0	7	89.2	6	104.8	98.30
Respiration rate after 48 hr. of stress	7	73.2	7	79.8	2	92.0	6	70.8	5	65.0	76.2
					Late						
Initial Respiration Rate	6	114.0	6	101.7	4	104.2	5	104.2	6	109.7	106.8
Respiration rate after 48 hr. of stress	4	76.0	4	63.0	4	59.5	5	63.0	4	78.7	68.0

changes noted in certain animals could not permit averaging. It is quite possible that by obtaining measures of central tendency the over-all pattern would be misrepresented or eliminated.

In some cases such difficulties may be eliminated by treating the data in terms of the amount of deviation from some basal level. This was not possible with the present apparatus, and the author knows of no method whereby respiration rate may be obtained on the rat under "normal" conditions. The initial measure in this situation followed immobilization, and, as would be expected, animals showed a highly elevated rate of respiration in response to the stress. It should be emphasized, therefore, that while no differences were demonstrated to exist between the initial level of respiration of the various groups in response to stress, the more desirable, and perhaps more sensitive, measure of the change from a resting state could not be applied to the data. The same is true for the measure of respiration after 48 hr. of stress.

The amount of available data on respiration was not sufficient to permit any kind of evaluation of the shape of the individual curves in terms of the *general adaptation syndrome*. Sample records are given in Fig. 6 and are discussed in conjunction with the measure of body temperature.

Body Temperature Under Stress

The possible involvement of the *general adaptation syndrome* under the conditions of stress imposed in the present study also provoked the measurement of body temperature. According to Selye (1950) hypothermia is characteristic of the *alarm reaction* (the initial response to stress). Similarly, other investigators (Bartlett, Bohr, & Helmendach, 1954; Bartlett, Bohr, Helmendach, Foster, & Miller, 1954; Grant, 1950) have demonstrated that the stress of restraint results in a hypothermic response. Of particular interest is the report that this hypothermia is more pronounced in the more emotional animals (Bartlett, Bohr, Helmendach, Foster, & Miller, 1954).

As with respiration, the first measure of body temperature was taken immediately following immobilization. While the physical manipulation involved in this process would certainly remove an animal from its resting state, it was assumed that a change in temperature would not come about as rapidly as a change in respiration. The change in temperature from this initial level is plotted in Fig. 5 for the first 8 hr. of stress.

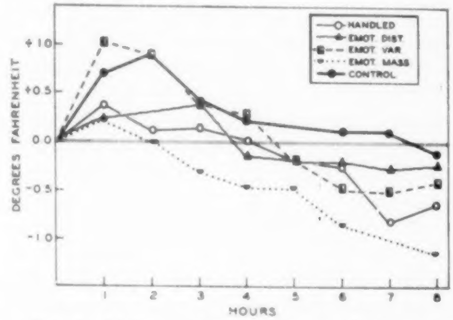

FIG. 5. Mean number of degrees of change in body temperature from initial body temperature during the first 8 hr. of stress.

Contrary to previous reports (Bartlett, Bohr, & Helmendach, 1954; Bartlett, Bohr, Helmendach, Foster, & Miller, 1954; Grant, 1950) the initial response to the immobilization was a hyperthermic one. For individual animals this hyperthermia preceding a hypothermic response lasted from 1 to 14 hr. Only 7 out of 26 animals showed a decrease in body temperature when the first measure ($\frac{1}{2}$–1 hr. after the initial measure) was taken, and these seven were dispersed in the five groups.

An F test revealed no differences in the mean change in body temperature from the original level between any of the groups during the first 8 hr. of stress. A summary of the analysis appears in Table L. In Table M is a summary of the analysis of body temperature taken after 48 hr. of stress. Again, the calculations were in terms of the degrees of change from the initial level, irrespective of the direction, and, again, the value of F was not significant.

Sample records of the body temperature and respiration rate of individual animals are shown in Fig. 6. These particular animals were chosen as representative of the variability in the magnitude and the time relations of the changes which occurred. They also illustrate the similarity in the course taken by both body temperature and respiration rate during a 48-hr. period of stress. Whether curves such as these may be interpreted in terms of Selye's *general adaptation syndrome,* and the problem of how this might be determined, is of interest but is of secondary importance to the present experiment. With respect to the problem at hand, visual inspection of the individual curves did not reveal any consistent pattern which might be associated with any particular type of previous experience.

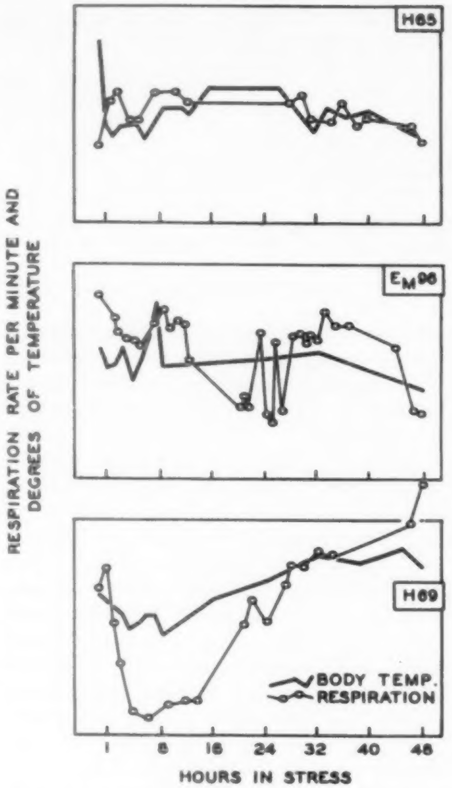

FIG. 6. Sample graphs of respiration rate and body temperature over 48 hr. of stress.

Loss in Body Weight Under Stress

Upon removing an animal from stress, a final weight measurement was recorded. The loss in body weight resulting from the immobilization was calculated in terms of the percentage of the prestress weight of the animal. The mean values for each group are given in Table 10. Since the F test is not applicable to percentage data with an upper limit, an arcsin transformation was applied to the data (Snedecor, 1946). A summary of the analysis of variance on the transformed data appears in Table N. The value of F was not significant.

Blood Clotting

While in the process of removing certain organs from the animals of Part A of the experiment, it was noted that the pools of blood which collected were sometimes clotted and sometimes not. It appeared, moreover, that the blood of nonstressed animals clotted faster than that of stressed

TABLE 10

Percentage of Loss in Body Weight Due to Stress

Period	Group H		Group E_D		Group E_V		Group E_M		Group C		Comb.
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	
Early	7	16.60	7	15.53	6	15.58	7	17.80	7	17.56	16.61
Late	6	15.35	6	14.68	6	14.73	5	17.78	5	15.84	15.68
Combined		15.97		15.10		15.16		17.79		16.70	

animals. In order to verify these original observations, the clotting time of animals of Part B was measured by a standardized method of analysis. The average blood coagulation time of the rat is 2.5 min. (Creskoff, Fitz-Hugh, & Farris, 1949). The animals in this study showed a range of from approximately 1.0 to approximately 5.0 min. The median clotting time was 3.3 and 2.0 min. for combined stressed and nonstressed animals, respectively.

The method involved in determining the coagulation time allowed only an ordinal scale of measurement. The median clotting times and the number of animals with clotting times above and below the over-all median of 3.0 min. are given in Table 11. Comparing the blood of all stressed with all nonstressed animals one finds that in 20 of 26 stressed animals 3 min. or more elapsed before coagulation took place. The blood of only 2 of 12 nonstressed animals required this much time. The probability that this difference is due to chance is .007 as determined by the Mann-Whitney U test.

A comparison of the several stressed groups using the Kruskal-Wallis one-way analysis of variance resulted in an H of 11.095 which is significant at the .05 level. Using the Mann-Whitney U test, independent comparisons were then made. The difference between Group E_M with a median of 2.75 min. and Group C with a median of 3.75 min. is significant ($U = O$, $p = .001$). The difference between Groups E_D and E_V and that between Group H and Groups E_D and E_V, taken together, were not significant at the .05 level. The only remaining independent comparison (Groups H, E_D, and E_V against Groups E_M and C) was also not significant at the .05 level. While it is difficult to draw conclusions on the basis of a limited number of independent comparisons, the similarity between the blood coagulation time of animals given the massed emotion-provoking stimulation (Group E_M) and nonstressed animals, and the relation of these to the remaining stressed groups, is worthy of note.

TABLE 11

Blood Clotting in Stressed and Nonstressed Animals (Part B)

Measure	Stressed: Groups H	E_D	E_V	E_M	C	Stressed: Combined	Nonstressed: Combined
N	6	6	4	5	5	26	12
No. animals with clotting time $\geq$ 3 min.	6	5	3	1	5	20	2
Median	3.25	3.40	3.25	2.75	3.75	3.3	2.0

Organ Weights

In Table 12 are given the organ weights for each of the stressed groups and the weights of stressed animals taken together. The organ weights of nonstressed animals have also been combined since in no case was there any indication of a difference between nonstressed animals as a function of experience. The mean values are given in grams per 100 grams of the prestress body weight.

Except in the case of the adrenal glands, the organs of early and/or late nonstressed animals differed in weight from stressed animals. The difference in size of all of the organs (roughly corresponding to the

TABLE 12

ORGAN WEIGHTS (GM./100 GM. OF BODY WEIGHT) FOR ALL GROUPS

Organ	Period	Stressed											Nonstressed	
		Group H		Group E_D		Group E_V		Group E_M		Group C		Combined	Combined	
		N	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean		*N*	Mean
Heart	Early	7	.282	7	.277	6	.287	7	.265	7	.265	.275	15	.313
	Late	6	.278	6	.296	6	.283	5	.344	6	.301	.299	12	.313
	Combined		.280		.286		.285		.304		.283	.287		.313
Liver	Early	7	2.893	7	2.922	6	2.778	7	2.624	7	2.928	2.830	15	4.090
	Late	6	2.778	6	2.688	6	2.553	5	2.366	6	2.809	2.648	12	3.594
	Combined		2.835		2.805		2.665		2.495		2.868	2.739		3.842
Kidneys	Early	7	.679	7	.615	6	.613	7	.578	7	.634	.624	15	.850
	Late	6	.655	7	.753	6	.696	5	.696	6	.709	.698	12	.837
	Combined		.667		.674		.654		.637		.671	.661		.843
Spleen	Early	7	.127	7	.124	6	.159	7	.119	7	.136	.132	15	.314
	Late	6	.173	6	.205	6	.142	5	.133	6	.187	.169	12	.257
	Combined		.150		.164		.150		.126		.161	.151		.285
Adrenals	Early	7	.0106	7	.0124	6	.0121	7	.0120	7	.0127	.0120	15	.0180
	Late	6	.0152	6	.0139	6	.0135	5	.0130	6	.0161	.0144	12	.0115
	Combined		.0129		.0131		.0128		.0125		.0144	.0132		.0147

differences in weight) are pictured in Fig. 7. These organs were removed from a stressed and nonstressed control animal of Part A of the experiment. The prestress body weight of these animals was exactly the same.

Heart.—In Table O a summary of the analysis of variance for the weight of the heart is given. The value of F for the difference between stressed and nonstressed animals with means of .287 and .313, respectively, is significant at the .05 level ($F = 6.70$, $df = 1$). The only other significant value of F is that for the interaction of the type of experience and the time (early or late in life) at which it occurred ($F = 2.55$, $df = 4$, $p < .05$). In order to determine which groups were responsible for this significant F, independent t tests were run between early and late animals having received the same type of experience. The difference between early and late animals having received emotion-provoking stimulation, regardless of the type or distribution, was significant. In the case of Groups E_D and E_M, late manipulated animals showed a greater weight of the heart than animals manipulated early in life ($p < .01$ in both instances). In the case of Group E_V early manipulated animals showed the greater weight ($p < .05$). No differences were demonstrated to exist between early and late groups of handled or control animals.

Liver.—A summary of the analysis of variance for the weight of the liver appears in Table P. As in the case of the heart, the 48 hr. of immobilization plus food and water deprivation resulted in a loss in weight of the liver ($F = 168.45$, $df = 1$, $p < .01$). For stressed animals the mean was 2.739 gm. and for nonstressed animals it was 3.842 gm./100 gm. of body weight.

The F value for the difference in the weight of the liver between early and late manipulated animals was also significant ($F = 15.32$, $df = 1$, $p < .01$), with groups manipulated early in life (with a mean of 3.22 as compared to a mean of 2.90 for late manipulated animals) showing the greater mean weight. None of the possible interaction effects yielded a significant value of F.

FIG. 7. Photograph of the organs of stressed and nonstressed control animals of Part A. The organ of the stressed animal appears on the right in each instance. Reading from top left to bottom right the organs are the heart, liver, kidney, spleen, and adrenal glands.

Kidneys.—Differences in the weight of the kidneys between stressed and nonstressed animals and between the various experience groups varied according to whether animals were manipulated early or late in life (Table Q).

While a t test did not reveal any difference between early and late nonstressed animals, the kidneys of animals stressed early in life (with a mean of .624 gm./100 gm. of body weight) weighed significantly less than those of animals stressed later in life (with a mean of .698 gm./100 gm. of body weight) ($t = 4.32$, $p < .01$). The differences between early stressed and nonstressed animals (with means of .624 and .850, respectively) and late stressed and nonstressed animals (with means of .698 and .836, respectively) were significant ($p < .01$ in both cases). Furthermore, the significant value of F for the interaction implies that the difference between early stressed and nonstressed animals is greater than that between late stressed and nonstressed animals ($F = 3.46$, $df = 1$, $p < .05$).

The F value for the interaction of experience and the time at which it occurred (early or late in life) was also significant ($F = 3.18$, $df = 4$, $p < .05$). The difference between early and late animals given the same emotion-provoking stimulus throughout the period of manipulation (early and late animals of Group E_D) was significant ($t = 5.88$, $p < .01$). No other differences between early and late animals having undergone a given type of experience were revealed to be significant.

Spleen.—Here again, the significant values of F (Table R) indicate that differences in the weight of the spleen between stressed and nonstressed animals and between the various types of experience varied according to whether animals were manipulated early or late in life.

With a mean of .132 gm. as compared to a mean of .169 gm./100 gm. of body weight the spleen of animals stressed early in life weighs significantly *less* than that of ani-

TABLE 13

ORGAN WEIGHTS (GM./100 GM. OF BODY WEIGHT) OF ANIMALS WHOSE FINAL BODY TEMPERATURE WAS HIGHER AND LOWER THAN THE INITIAL TEMPERATURE

Measure	N	Heart	Liver	Kidneys	Spleen	Adrenals
Final temperature higher than initial temperature	8	.308	2.715	.690	.185	.0153
Final temperature lower than initial temperature	15	.294	2.607	.709	.156	.0140

mals stressed later in life ($t = 4.47$, $p < .01$). In the case of nonstressed animals, the weight of the spleen of early manipulated groups (with a mean of .314 gm.) is significantly *heavier* than that of late manipulated groups (with a mean of .257 gm./100 gm. of body weight) ($t = 4.39$, $p < .01$).

The differences between early stressed and nonstressed animals (with means of .132 and .314, respectively) and late stressed and nonstressed animals (with means of .169 and .257, respectively) were significant ($p < .01$ in both instances). As in the case of the kidneys, the difference between early stressed and nonstressed animals is greater than that between late stressed and nonstressed animals as indicated by the significant value of F for the interaction ($F = 8.24$, $df = 1$, $p < .01$).

As for the interaction of experience and the time at which it occurred ($F = 4.44$, $df = 4$, $p < .01$) no differences were demonstrated to exist between early and late animals of Groups H, E_M, or C. Comparing early and late manipulated animals of Group E_D (a mean of .164 as compared to a mean of .234) resulted in a t of 4.49 which is significant at the .01 level. In the case of Group E_V, animals manipulated early in life show the greater weight of the spleen with a mean of .235 as compared to a mean of .160 gm./100 gm. of body weight for late manipulated animals ($t = 4.52$, $p < .01$).

Adrenals.—A summary of the analysis of variance for the weight of the adrenal glands appears in Table S. The value of F failed to reveal differences under any conditions.

In order to determine whether any relationship existed between the change in body temperature and the organ weights under stress, a comparison was made of the organ weights of those animals showing an increase and those showing a decrease in body temperature after the 48 hr. of immobilization. Omitting those animals whose body temperature after 48 hr. of stress was the same as their initial temperature, and irrespective of group, the number of animals whose body temperature was greater than their initial temperature was 8, and the number showing a decrease in temperature was 15. The organ weights of these two groups are given in Table 13. With the exception of the kidneys, the weights of the organs of animals whose body temperature increased over the initial level tended to be greater than those of animals showing a decrease in body temperature. In no case, however, did t tests reveal any significant differences between the groups.

Relative Performance of the Several Groups

Except in the case of activity in the Y maze, defecation in the open field, and the number of entries into an inner circle of the open field, no differences were demonstrated to exist between the several groups subjected to differential treatments. Despite this lack of statistical significance on a given measure, the relative position of the groups with respect to one another was observed to be fairly constant from one test situation to another. One may inquire, then, concerning the probability that a given group would show a score indicative of greater emotionality (with respect to some other

TABLE 14
RANKINGS OF ALL GROUPS ON THOSE MEASURES CORRELATED WITH EMOTIONALITY

Measure	Part	Group				
		H	E_D	E_V	E_M	C
Emergence from cage (I)	A	1	2	3	5	4
	B	2	5	3	4	1
Emergence from cage (II)	A	5	2	1	4	3
	B	5	1	4	2	3
Activity in open field	A	1	4	2	3	5
	B	1	2	4	5	3
Open field						
Concentric Circle 2	A	1	2	3	5	4
	B	1	3	2	4	5
Concentric Circle 3	A	2	3	1	4	5
	B	2	3	1	4	5
Concentric Circle 4	A	1	2.5	2.5	4	5
	B	2	3	1	4.5	4.5
Defecation in the open field						
Mean	B	1	2	4	5	3
N		1.5	1.5	3	5	4
Latency in the Y maze	A	4	5	1	3	2
	B	1	2	5	3	4
Activity in the Y maze	A	1	3	2	4	5
	B	1	2	4	5	3
Defecation in the Y maze						
Mean	B	1	2	3	5	4
N		1	2	4	5	3
Weight of adrenals (stressed animals)	A	5	2	3	4	1
	B	2	3	4	5	1
Sum of the Ranks		42.5	57.0	60.5	92.5	77.5

group) over a series of tests even though individual tests of the series failed to discriminate between these groups.

Each of the five groups were ranked on all of the tests employed in the experiment. In Table 14 appear the rankings on those measures which are considered indices of emotionality. The lower numbers refer to the less emotional groups. In order to be more conservative, and because they do represent different tests in the sense that they were performed on different animals, Parts A and B were ranked separately. Wilcoxon's (1941) rank test for the comparison of several treatments was used in a preliminary analysis of the data. The value of $\chi^2 r$ was 27.39 which is significant beyond the .001 level of confidence. Applying Wilcoxon's signed-ranks test (Siegel, 1956; Wilcoxon, 1941) to individual pairs resulted in the following:

No differences were demonstrated to exist between Groups E_M and C. Group E_M is significantly different from the other manipulated groups in the direction of greater emotionality ($p < .01$). Although Group E_V differs from Group E_M, no differences were revealed between Group E_V and control animals on the one hand and the remaining manipulated groups (H and E_D) on the other. While handled animals are somewhat less emotional than animals given the same, distributed emotion-provoking stimulation (Group E_D) ($p < .05$), both of these groups are less emotional than either control animals or those given the massed emotion-provoking stimulation (Group E_M) ($p < .025$).

Discussion

The results from the various tests employed in the experiment support only partially, and with certain qualifications, the hypothesis that both handling and emotion-provoking stimulation of a nontraumatic nature, if distributed throughout early life, are capable of raising the threshold for emotional reactivity. Discussing first the behavioral situations used to elicit responses indicative of emotionality, as opposed to the physiological reactions to the subsequently imposed stress, one must say that the majority of the measures failed to differentiate between the several groups given different types of manipulation early or late in life. Even so, the relationship of greater or lesser emotionality among the several groups remained fairly constant (and significantly so) over the various test situations, and the direction of the relative position of the groups, in terms of emotionality, does offer some support for the hypothesis. There was no evidence, on the other hand, that, in the situations employed, manipulation early in life resulted in behavior demonstrably different from that effected by such manipulation at a later time.

Except for the second emergence-from-cage test (Parts A and B) and the latency score in the Y maze (Part A only) handled animals appeared to be less emotional than control animals in the various test situations. It had previously been reported (Hunt & Otis, 1955) that handled animals required less time before emerging from their cages; and so they did in the first test of this experiment. In the second test, although the result was not statistically significant, both early and late handled animals required more time than any of the other groups. The lesser emotionality displayed by handled animals relative to nonmanipulated controls was significant in the case of defecation and number of entries into concentric Circle 3 of the open field, and in activity in the Y maze. For those tests which did not yield statistically significant results, the tendency for handled animals to be less emotional than nonmanipulated controls was, as revealed by a comparison of the ranks on the various tests, statistically significant.

That handled animals are less emotional than controls is consistent with Weininger's (1956) results and other previous studies (Ader, 1957; Hunt & Otis, 1955). It fails to confirm the results obtained by Scott (1955) who found no differences between ignored animals and those handled for 3 min. per day. In the introduction to the present study it was maintained that the difference in the amount of handling administered by Scott and Weininger could not have accounted for the discrepancy in their results. This was based on the finding that 3 min. of handling was sufficient to reveal differences between handled and nonhandled animals (Ader, 1957). In this preliminary study the open field and Y maze were the test situations. Only the former differentiated between the groups. Although in the same direction, results from the Y maze were not significant. In view of the present observations that only a few of the many tests employed revealed statistically significant results, while those that remained only confirmed the direction of the emotionality among the groups on those tests showing significance, it seems that the amount of manipulation could have accounted for the difference in results.

In Group E_V we have animals exposed to an emotion-provoking situation equal in distribution and duration to the handling procedure, but in this case the emotion-provoking stimuli varied on successive occasions. Group E_D was found to differ significantly from Group E_V only in the greater number of times animals of Group E_V entered concentric Circle 3 of the open field. The only other situations differentiating between the several groups were defecation in the open field and activity in the Y maze. In the former, Groups E_D and E_V did not differ. Both were more emotional than handled animals on the one hand, and less emotional than control animals on the other. In the Y maze also, Groups E_D and E_V did not differ between themselves.

On those tests which did not yield statistically significant results, Groups E_D and E_V performed in much the same manner, as indicated by the very small and nonsignificant difference in the sum of the rankings over the various tests. Both groups tended to be less emotional than control animals; however, only Group E_D with the slightly *lower* rank differed significantly from the controls. Group E_V with the slightly higher ranking did *not* differ from handled animals, while the difference between Groups E_D and H was significant. It appears, then, that although there is a tendency for handled animals to be somewhat less emotional than animals subjected to distributed emotion-provoking stimulation, both such treatments tend to effect a heightened threshold for emotional reactivity relative to unmanipulated animals. Again, while there were few differences demonstrated from specific tests, the over-all tendency is consistent with the hypothesis.

That it was a distribution of the emotion-provoking stimuli, as opposed to emotion-provoking stimuli per se that was effective, is indicated by the finding that animals exposed to massed emotion-provoking stimulation were more emotional than Groups E_D and E_V as well as handled animals. This was true in practically every case. On those tests which differentiated between the groups, animals of Group E_M did not differ from control animals. The same was true of the over-all rankings, although this group did tend in the direction of being more emotional than any of the other groups.

The finding that animals exposed to emotion-provoking stimulation equal in distribution and duration to the handling procedure tend to be less emotional than unmanipulated control animals re-

inforces the interpretation advanced to account for certain previous results. It will be remembered that Griffiths and Stringer (1952) failed to demonstrate differences between groups of animals subjected to noxious stimulation and controls which received approximately the same treatment except for the noxious stimuli. Also, Stanley and Monkman (1956) failed to demonstrate differences in emotionality between animals given electric shock and control animals placed into the apparatus without shock. It was suggested that the control animals of these studies were comparable to the handled animals of a preliminary study (Ader, 1957) and the present experiment. The slight difference in some cases and the lack of differences in emotionality in others between handled animals and those exposed to the distributed emotion-provoking experience, and the superiority of these groups over controls, are results similar to those obtained by Chevalier and Levine (1955) and Levine et al. (1956). Taken together, these results argue for the inadequacy of the control groups manipulated by Griffiths and Stringer, and Stanley and Monkman, and support, in the main part, the hypothesis that both handled animals and those exposed to emotion-provoking stimulation will display less "emotional" behavior than control animals. The fact that animals subjected to the distributed emotion-provoking stimulation tend to be somewhat more emotional than handled animals is also consistent with the fact that, in Chevalier and Levine's studies, animals given electric shock sometimes differed from no-shock, handled animals. Although in both experiments the experimental groups performed similarly with respect to unmanipulated animals, both experiments also suggest that these experimental groups were somehow different. Whether this difference, should it be a real one, is quantitative or qualitative could not be answered from the data of the present experiment.

The results discussed thus far bear some similarity to those obtained by Griswold and Gray (1956). Working on a physiological level, these investigators hypothesized that sublethal autonomic stimulation would effect a heightened threshold (in terms of mortality rate) to subsequent traumatic stimulation in the Noble-Collip drum. Using electroconvulsive shock as the autonomic stimulant, their hypothesis was confirmed. Pretreatment with ECS reduced the mortality rate due to tumbling trauma in the experimental animals. It had previously been found that sublethal doses of trauma in the drum resulted in the development of resistance to such lethal stimulation (Noble, 1943; Noble & Collip, 1942). That resistance could be built up by previous stimulation which was qualitatively different from the traumatic stimulation to be imposed suggests that the experimental animals do not build up resistance in terms of the transfer of some specific experience.

The question of the influence on emotionality of the repetition of an emotion-provoking stimulus to which the animals may be able to adapt, as opposed to stimulation which does not allow of such adaptation, is answered by reference to Groups E_D and E_V. The latter group, subjected to a variety of noxious stimuli, was not different from those given the same emotion-provoking stimulation on successive occasions. In fact, the difference between these groups is less than that between any others. It appears, then, that whatever part of the heightened reaction threshold to emotion-provoking situations may be described as a transfer effect is a transfer of some general rather than specific adaptive response made to the previously experienced emotion-provoking stimulation.

Of the behavioral measures, only the test involving first emergence from cage revealed an interaction between experience and the time at which it occurred. While nonmanipulated control animals required about the same amount of time to emerge from their cages whether tested early or late in life, all of the experimental groups manipulated early in life were less emotional than their late manipulated counterparts. This finding that the effects of experience vary with the time of manipulation was not confirmed by any of the remaining behavioral situations.

In the case of the second emergence-from-cage test, activity in the open field, entries into concentric Circle 3 of the open field, and latency in the Y maze, animals tested early in life were less emotional than animals tested later in life, regardless of the type of manipulation experienced. With the exception of activity in the Y maze, the remaining measures also showed a tendency for animals tested early in life to be the less emotional.

With regard to the behavioral measures in this experiment, then, the hypothesis that manipulation early in life is particularly crucial in effecting a heightened reaction threshold to emotion-provoking situations was not confirmed. The results indicate that young animals respond to the situations employed with less of what may be described as emotional behavior regardless of the type of manipulation experienced or whether they were manipulated at all.

With regard to the rate of growth of the several groups as measured by the percentage of increase in body weight over the initial weight, no differences were demonstrated. While consistent with Scott's (1955) findings, such results fail to add support to the present hypothesis and fail to confirm the results of other investigators (Bernstein, 1952; McClelland, 1956; Weininger, 1956; Weininger et al., 1954). That animals which were handled and those which were exposed to the distributed emotion-provoking stimulation late in life (Groups H, E_D, and E_V) showed an initial loss in body weight at the beginning of the period of manipulation is in line with the suggestion that these types of stimulation are, initially at least, responded to in the same way. When Group E_M was first manipulated they, too, showed a decrease in body weight. As was pointed out, however, too

much emphasis should not be placed upon such data due to the loss in body weight shown by all groups at some time during the period of manipulation.

It is not surprising that animals manipulated early in life did not show this initial weight loss. The rapid growth characteristic of young animals would most probably have covered up such a tendency. Moreover, it is possible that this initial tendency to lose weight in response to the external stimulation is responsible for the observation that when handled animals are heavier than controls, the weight difference first becomes manifest (or becomes greater) late rather than early during the period of manipulation (Greenman & Duhring, 1923; Weininger, 1956).

Weininger (1956) was unable to demonstrate differences between gentled and nongentled animals in the percentage of loss in body weight after 48 hr. of immobilization and food and water deprivation. In the present study, also, the percentage of loss in body weight due to stress did not differentiate between the several groups. It is of interest, however, that the relative position of the groups for both Parts A and B was similar to the rankings for emotionality, with Groups E_M and C showing the greatest loss in body weight.

In a previous study (Herrington & Nelbach, 1942) it was shown that animals subjected to various noxious stimuli ("disturbed" animals) showed a greater body weight than nonmanipulated controls. The greater body weight of "disturbed" animals relative to controls is similar to the relation between gentled and nongentled animals in Weininger's (1956) study. The greater weight of the adrenals of "disturbed" animals relative to controls is not like Weininger's study in that the nongentled animals in his experiment showed the greater adrenal weight. In view of these observations it was suggested that, should greater resistance to stress be displayed by handled animals and those groups exposed to the distributed emotion-provoking stimulation, the physiological mechanisms mediating such resistance in these groups might be different.

From the behavioral tests in the present study it was observed that, although both handled animals and those exposed to the distributed emotion-provoking stimulation tended to be less emotional than controls, these groups differed slightly among themselves. Chevalier and Levine (1955) and Levine et al. (1956) also found that, while differing from unmanipulated controls, their experimental groups did differ somewhat from each other. These observations are consistent with the suggestion made above concerning different mechanisms mediating resistance to stress in handled and "emotionalized" animals.

On a physiological level, however, the results did not, in general, offer reliable evidence for the existence of differences between the several groups, nor did they offer convincing evidence that the mechanisms called into action by the stress were different in the case of any of the groups. Of course, even had differences in resistance been demonstrated to exist, a difference in the mechanisms mediating such resistance might not have been revealed by such a simple measure as the weight of the various organs.

Although the respiration data were, in general, insufficient for complete analysis, the patterns obtained over the 48-hr. period of stress did not even suggest any consistency which might have been associated with a particular group. The initial respiration measure, representing the expected high rate characteristic of an emergency reaction, did not differentiate between the groups, nor did the respiration rate recorded at the end of the stress period. The same was true for the measure of body temperature which was only recorded for animals manipulated late in life. Whether there are, in fact, no differences to be discerned, or whether these observations are due to the great variability shown by these functions (let alone the sparseness of the data) cannot be said with certainty. Although not bearing upon the aims of the present research, the frequently observed tendency for the patterns of change of respiration rate and body temperature to progress in a similar manner over the 48 hr. of stress seems worthy of note.

Because of the observations of Grant (1950), Bartlett, Bohr, and Helmendach (1954), and Bartlett, Bohr, Helmendach, Foster, and Miller (1954) that the initial response of the body temperature to a stress situation is a hypothermic one, and the suggestion that the degree of hypothermia is related to the emotionality of the animal (Bartlett, Bohr, Helmendach, Foster, & Miller, 1954), special attention was given to the first 8 hr. of stress. Contrary to the results cited above, the initial response to the immobilization was a hyperthermic one. Furthermore, the differences in emotionality observed in the behavioral tests did not reveal themselves in terms of the degree of hyperthermia or the time taken before the body temperature returned to the initial level.

These results, however, are in accord with observations on man. Goodell, Graham, and Wolff (1950) found an increase in body temperature to follow upon muscular exercise, and, under a stressful situation, the time required before this temperature returned to the previously established baseline was increased. Such a rise in body temperature under stress has been termed "neurogenic hyperthermia" by Friedman (1950) who describes it as "a phenomenon that spontaneously erupts in patients exhibiting a particular type of autonomic instability primarily characterized by sympathetic over-reactivity to internal or external stress" (p. 440).

Although not directly relevant to the present hypothesis, the data on blood clotting also deserves further discussion. Contrary to what might be expected on the basis of Cannon's (1932) emergency reaction, the time required for the blood to

clot was greater in the case of stressed than nonstressed animals. While there are numerous studies which report a shortening of the coagulation time of individuals exposed to emotion-provoking stimulation or stress, there are relatively few studies reporting a lengthening of the clotting time, and there are no studies known to the author which treat of this subject in a systematic manner.

Although they did not discuss it in theoretical terms, Cannon and his co-workers were aware that emotion-provoking stimulation sometimes resulted in an increased clotting time (Cannon & Mendenhall, 1914; Gray & Lunt, 1914). These incidental observations, usually discussed in a footnote, were accounted for in more or less the same way, i.e., "In many experiments the decreased coagulation time rises again not only toward normal as expected, but above. This secondary rise appears due in some cases to reaction in excess, so often remarked in biological processes when opposing factors are at work" (Gray & Lunt, 1914, p. 336), or, the increased clotting time is due "to the use of animals which had been kept for some time in conditions likely to discharge the adrenal glands" (Cannon & Mendenhall, 1914, p. 260).

More recent literature, as reviewed by Selye (1951), does not contribute a solution to the problem of determining the conditions under which there is an increase or decrease in the time required for the blood to clot. The position taken here is that Cannon's (1932) discussion of the increase in clotting time is essentially correct. It is felt, however, that such observations merit a more complete analysis, and the approach recommended is one of determining the changes in blood clotting time over extended periods of emotion-provoking stimulation. Although seemingly obvious, the past history and stimulus employed should be well controlled, precautions which have apparently been ignored (see especially Haden, Schneider, & Underwood, 1948; Scott & Crosby, 1954).

As in the case of HCl secretion in stress situations (Mahl, 1952, 1953), blood-clotting time may be found to vary with the chronicity of the stress and to provide additional support for theoretical analyses and practical therapy based on the distinction between acute and chronic disorders. Another line of research may lie in the personality correlates of alterations in the blood-clotting mechanisms. For example, Macht (1952) has observed that the clotting time of highly nervous blood donors is significantly faster than that of calm individuals, an observation consonant with Cannon's position. Schneider and Zangari (1951) also report decreases in blood-clotting time to a number of *acute* stress situations, but they also found that "when a subject's feeling state could be described as hopeless, sad, depressed, or defeated" (p. 300), the clotting time was significantly lengthened. In this same study they report that while adrenalin injections effect a decrease in clotting time, noradrenaline injections result in a lengthening of the process. The above observations seem somewhat at odds with Funkenstein's (1955) distinction between "anger-in" (depression) with its adrenalin-like reaction, and "anger-out" (rage) with its noradrenalin-like reaction.

The final measures of the present study were of the weights of the various organs. In terms of the degree of resistance to the stress of immobilization and food and water deprivation displayed by the groups given the various types of manipulation, the results offered no support for the suggestion that emotion-provoking stimulation as well as handling would result in a greater resistance to stress than would be evidenced by the nonmanipulation of animals.

As might be expected, the organ weights of stressed and nonstressed animals differed in most cases. There was a decrease in the weight of the heart and liver regardless of the type of manipulation or the time at which it occurred. Because of the involvement of the liver in the blood-clotting mechanism it should be mentioned that the loss in weight of this organ was due, in the main, to the release of stores of glycogen in response to the food and water deprivation accompanying immobilization. Moreover, it has been demonstrated that the prothrombin time is not appreciably affected even when 50% of the liver is damaged (Martin, 1945). It is not likely, therefore, that the clotting time of stressed animals was influenced by the loss in weight of the liver.

In the case of the kidneys and spleen, the difference between stressed and nonstressed animals was a function of whether stress was imposed early or late in life. In both instances, the weight of the organs of animals stressed early in life was less than that of animals stressed late in life. And while the organs of stressed animals weighed less than that of nonstressed animals, this loss was greater in the case of early manipulated animals.

The weight of the adrenal glands did not differ in animals manipulated early or late in life or as a function of the type of manipulation experienced. These results fail to confirm Weininger's (1954, 1956) observations and, on a larger scale, the observations of numerous studies concerning the adrenal glands in the organism's response to stress (see Selye, 1950). The reason for these findings is not apparent. The simplest explanation might be that the stress situation was not sufficiently severe to effect adrenal enlargement. Fortier (1949), however, found a significant decrease in the weight of the adrenals after only 38 hr. of immobilization. This observation, Weininger's results, and the findings of the present study with respect to the loss in weight of other organs would not make plausible the hypothesis that the stress was not sufficiently severe.

One could go to the other extreme and hypothesize that the stress situation was so severe as to cause, or begin to cause, changes in the various organs which indicate complete exhaustion. It has

been found, for example, that there is a *decrease* in the weight of the adrenal glands of individuals who were exposed to an intense, continuous stress which ended in death (Uotila & Pekkarinen, 1951). It appears that "in experimental animals and in man, continuous severe stress will eventually exhaust the adaptation energy of the body and lead to a 'stage of exhaustion'" (Selye, 1951, p. 26). The lack of differences in the adrenal weights of stressed and nonstressed animals in the present study may be due to sacrificing the animals just at the time when the hypertrophied adrenal glands were displaying a decline in weight signaling exhaustion. Since no histological or chemical analyses were performed, there is no corroborative evidence for such a suggestion. It is made all the more reasonable, however, in light of the increase in blood-clotting time, which indicates that the animals were no longer responding to an *acute* situation, but one under which the adrenals had become nearly exhausted (Cannon & Mendenhall, 1914).

If one makes the above assumption, then it is not surprising that differences were not demonstrated to exist among the groups. As with an overdose of thiourea (Scott, 1955), all animals succumbed under the severity or chronicity of the situation.

The difficulty with this suggestion is that, to be consistent, one would have to reinterpret Weininger's results and maintain that the heavier weight of the adrenals of nonhandled animals was indicative of sustained resistance rather than greater damage, a conclusion which would appear to be at odds with the remainder of his findings (emotionality, cardiovascular damage, and gastrointestinal erosions). Using only gross measures, the cardiovascular changes noted by Weininger might be characteristic of either the initial response to the stress or a stage of exhaustion (Selye, 1950). The fact that handled animals showed virtually no erosions along the gastrointestinal tract, however, is not characteristic of animals in a state of physical exhaustion and suggests one further argument in an attempt to interpret the present findings in terms of the severity of the stress situation and yet allow for the conclusion that the handled animals in Weininger's study were the more resistant.

In order for the present results and those of Weininger to be consistent it is postulated that the differences in the stress situations employed were sufficiently great so that the animals in the present study were further along in their ultimate collapse under the stress than was the case in Weininger's study. There appear three main reasons why this might be so. In the first place, there are those differences in animals resulting from differing strains and care in different laboratories. Secondly, in Weininger's two experiments involving immobilization, the stress was imposed when the animals were 79 days of age in one, and 59 days of age in the other. In the present study, animals of Part A were immobilized at 87 days of age and animals of Part B at 200 days of age. Finally, although immobilization by means of adhesive tape and gauze was attempted, the wire mesh employed proved considerably more adequate in terms of reducing the amount of struggling. In this situation, the head also was completely immobile, which was not the case in Weininger's study. If, on the basis of these variables, the stress situations in the two studies may be considered sufficiently different, then it is possible that, despite the equal period of stress, greater damage was experienced by the animals in the present experiment.

In theorizing about the results obtained by Weininger, Bovard (1954) has postulated that the differences between handled and nonhandled animals is due to a reduction in handled animals of the activity of the sympathetic nervous system to emotion-provoking stimulation. Similarly, Griswold and Gray (1956), attempting to account for the observations that sublethal stimulation in the Noble-Collip drum effects a resistance to subsequent traumatic stimulation in that situation, have confirmed their hypothesis that a repetition of autonomic activity can result in a gradual alteration in the character of the process so that sympathetic activity is decreased upon subsequent exposure to traumatic stimulation.

Since there is independent research which would lead one to believe that animals react to handling as an emotion-provoking experience (Tryon et al., 1941a, 1941b), and emotion-provoking stimulation of the kind used in this study does elicit autonomic types of activity (Vogt, 1954) one might predict that both handled animals and animals subjected to emotion-provoking stimulation would show greater resistance to stress than unmanipulated controls, and that this resistance is effected by the previously experienced autonomic stimulation.

The failure to find differences in the resistance to stress of the various groups in the present study offers no support for the hypotheses of Bovard and Griswold and Gray. Nevertheless, the results from the behavioral tests are suggestive, since both handled animals and those subjected to the emotion-provoking stimulation tended to be less emotional than nonmanipulated animals. It should not be overlooked, however, that these experimental groups differed somewhat among themselves.

If one assumes that the heightened reaction threshold to the emotion-provoking situations resulted from the previous autonomic stimulation, then it would appear that the degree of autonomic activity effected by handling and emotion-provoking stimulation is different, or that there is more involved here than simply the reactivity of the autonomic nervous system. Of course, one need not make this assumption, but rather, hypothesize that the lesser emotionality or increased resistance displayed by these groups was a result of entirely different mechanisms. Theoretically, these suggestions could be investigated by measuring the

autonomic activity of the several groups at the time of manipulation.

Summary and Conclusions

This study was designed (*a*) to test the hypothesis that both handling and emotion-provoking stimulation of a nontraumatic nature and distributed throughout early life (as opposed to manipulation at maturity) is capable of raising the threshold for emotional reactivity to subsequent emotion-provoking situations and (*b*) to investigate the effects of handling and various other types of emotion-provoking stimulation on subsequent resistance to stress.

Split-litter groups of animals, representing the following five types of experience, received 30 days of manipulation early (beginning at 23 days) or late (beginning at 136 days) in life.

Group H was handled for approximately 3-4 min. per day in a nonsystematic manner.

Group E_D animals were placed individually into a cylindrical wire cage suspended from an overhanging beam. In this position animal and cage were lifted and allowed to swing freely.

Group E_V was exposed to a variety of emotion-provoking stimuli which differed from day to day. For both Groups E_D and E_V the emotion-provoking stimulation was equal in duration to the handling procedure.

Group E_M was exposed to the same emotion-provoking stimulation as Group E_V; however, in this case they were all presented on the same day.

Group C served as controls, experiencing no manipulation by the experimenter other than the proximity associated with their care and being weighed weekly, as were the experimental groups.

Fifteen days after the last day of manipulation, all animals were tested for emotionality in an emergence-from-cage test, an open-field situation, a Y maze, and a second emergence-from-cage test. After a week without further testing, animals from each group were weighed and then immobilized in wire mesh and remained so for 48 hr. without food or water. Those animals from each group (stress controls) which were not subjected to the immobilization were not manipulated during this time.

During the 48-hr. period of stress, a record of respiration rate was taken. For animals manipulated late in life, body temperature was also recorded. At the end of the stress period all animals were weighed, injected with nembutal, and sacrificed. The heart, liver, kidneys, spleen, and adrenal glands were removed and placed in coded jars of formaldehyde where they remained for approximately one week before being weighed. For late manipulated animals the time required for their blood to clot was also recorded.

Only a few of the many measures obtained from the behavioral tests of emotionality differentiated between the several groups. The relative performance of the several groups in terms of greater or lesser emotionality, however, was significantly constant from all the measures on one test to all those of another, and the direction of these differences were consistent with the results of those measures differentiating between the groups, and with the hypothesis. The over-all emotionality of animals subjected to the massed emotion-provoking stimulation did not differ from that of control animals, but was greater than that for the other experimental groups. The two groups given the distributed emotion-provoking stimulation did not differ. Although there was a tendency for handled animals to be somewhat less emotional than animals subjected to distributed emotion-provoking stimulation, both such treatments tended to effect a heightened threshold for emotional reactivity relative to unmanipulated animals.

The hypothesis that manipulation *early* in life is particularly crucial in effecting a heightened reaction threshold to emotion-provoking situations was not confirmed. The results indicated that young animals respond to the situations employed with less emotionality regardless of the type of manipulation experienced or whether they were manipulated at all.

The rate of growth and loss in body weight under stress did not differentiate between the several groups, offering no

support for the hypothesis. There was evidence, however, which suggested that both handled animals and those given emotion-provoking stimulation tend to lose weight as an initial response to the manipulation.

No support for the hypothesis was afforded by any of the physiological measures obtained during or after the stress situation. The lack of physiological differences between the groups was accounted for by postulating that the stress situation was so severe that all animals were in a state of exhaustion at the end of the 48-hr. period.

Incidental to the hypothesis being tested, it was observed that the pattern of change of respiration rate was similar in a given animal to that of body temperature over the 48 hr. of stress. Also, the blood-clotting time of stressed animals was greater than that of nonstressed animals.

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